Theodore Cooper

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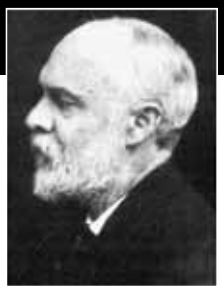

Theodore Cooper.

Theodore Cooper was born on January 13, 1839 in Cooper's Plain, New York. He prepared for college by going back to Easton, Pennsylvania (his mother's hometown) and studying at John Vanderveer's Academy. In 1855, he entered Rensselaer Polytechnic Institute. Graduating in 1858, he went to work on the Hoosac Tunnel and the Troy and Greenfield Railroad. He entered the Navy at the outbreak of the Civil War and served on the gunboat, Chocura, throughout most of the War. After the war, he split his time between being an instructor at the Naval Academy at Annapolis, Maryland and served on naval ships.

In 1872, Cooper resigned from the Navy and went to work for James Eads on the St. Louis Bridge. After serving as inspector at the plant making the steel and later for the firm fabricating the steel, he was placed in charge of construction of the bridge. Eads was away for long periods of time seeking funding for the bridge and regaining his strength after several illnesses. Cooper, along with Henry Flad, C. Shaler Smith, Jacob Hays Linville and Walter Katte of the Keystone Bridge Company, was given a great deal of responsibility for the actual process of cantilevering the steel arch pieces out over the river.

After completion of the bridge, Cooper became its chief engineer before going to the Delaware Bridge Company at Phillipsburg, New Jersey to work with Charles Macdonald. He then went to work for the Keystone Bridge Company under Jacob Hays Linville.

By 1879, Cooper had established himself to such a degree that he became a consulting engineer with offices in New York City. In this capacity, he consulted on many major bridge structures throughout the northeast. These were the Seekonk Bridge in Providence, Rhode Island, the Sixth Avenue Bridge across the Allegheny River in Pittsburgh, the Second Avenue Bridge across the Harlem River in New York City, the Newburyport Bridge over the Merrimack River in Massachusetts and the Junction Bridge across the Allegheny River. The Sixth Avenue Bridge replaced John A. Roebling's twin span suspension bridge built in 1859, which in turn replaced Lewis Wernwag's wooden bridge. It was a two span bridge with bowstring trusses spanning 439 feet 3 inches. It was built in 1893 around the existing bridge by the Union Bridge Company. It was removed in 1927 and rebuilt at Coraopolis, Pennsylvania.

In 1884, Theodore published his "General Specifications for Iron Railroad Bridges and Viaducts" forming, in the words of the *Engineering News-Record*, the "first authoritative specifications on bridge construction that had been published and circulated." While he contributed many articles to the Transactions ASCE, his two most well received articles, for which he received the Norman Medal, were those entitled *The Use of Steel for Bridges* in 1879 and *American Railroad Bridges* in 1889.

In 1895, he was appointed a member of a Board of Consultants by President Cleveland to determine what the span for a bridge across the Hudson River should be to maintain river traffic. Charles Macdonald of the Union Bridge Company had proposed a 2,400-foot span cantilever. Cooper, as a member of the Board, prepared a design for a 3,100-foot suspension bridge for estimating purposes. The Board rejected the cantilever proposal of Union Bridge due to its having a pier in the river. Union Bridge later prepared plans for a 3,100-foot span suspension bridge much like Cooper's design, but the bridge was not built due to lack of funding.

In 1899, Cooper was at the pinnacle of a long and successful career at the age of 60. If he retired at that point, he would rank among his contemporaries as one of the great engineers of the latter part of the 19th century. However, he became associated with a proposal to build a large bridge across the St. Lawrence at Quebec. He was first approached by the Quebec Bridge Company to serve as consulting engineer to review the plans that were submitted. They used an earlier Phoenix Bridge cantilever design as a base plan, but indicated they would entertain other designs. They received proposals from four of the largest bridge companies. They were the Phoenix Bridge Company, the Dominion Bridge Company, the Keystone Bridge Company and the Union Bridge Company.

Cooper reported on June 30, 1899, determining "The Phoenix plan was slightly lower in estimated cost" and he thought it "an exceedingly creditable plan from the point of view of its general proportions, outlines and its constructive features" and it was the "best and cheapest plan and proposal of those submitted to me..."

He was then asked to follow up on the suggestion made earlier that a 1,800-foot span might be more economical, given the better foundation sites that would be associated with a span of this length. He reported on May 1, 1900 "after a careful consideration of all the conditions by your chief engineer, Mr. E.A. Hoare, and myself, it was decided that an 1,800-foot channel span was most desirable if the expense was not too great."

Within a week of submitting his report and having it accepted, he was appointed consulting engineer to oversee the final design and construction of the longest cantilever bridge in the world. Work on the foundations started late in 1899. During mid-1900 to mid-1903, some work continued on the design and details of the anchor and cantilever spans, but funding problems delayed actual work until 1905.

Government financial support on the Quebec Bridge was not received until 1903, at which time a final contract was signed with the Phoenix Bridge Company. Cooper made several changes to the specifications that later would be partly responsible for the bridge failure. The first was a reduction in wind load from 56 to 30 pounds per square foot. In addition, he recommended an increase in rolling loads and an increase in allowable working stresses in the members to 20,000 pounds per square inch under a Cooper E-30 loading and 24,000 pounds per square inch under a Cooper E-50 loading over the entire length of the bridge.

The Phoenix Bridge Company designed the bridge in accordance with Cooper's revised specifications, and fabrication and construction of the superstructure began. In June 1907, Szlapka of the Phoenix Bridge Company reported to Cooper that the weight of steel delivered to the site was much higher than was used for dead weight in the design. It turned out that Szlapka used dead weight estimates from the earlier 1,600-foot span design and had not updated them for the 1,800-foot span. He reported the total assumed weight for the entire bridge was low by 7.5 million pounds, and the weight of half the suspended span plus the cantilever arm was 3.5 million pounds higher than the 18 million pounds assumed. This was a major mistake and should have caused much greater alarm than it did. Cooper rationalized it by saying that the error only increased the stresses by 7 to 10%, and that was still acceptable. The Board accepted Cooper's opinion, and work continued. With this error, the fate of the bridge was probably already decided.

Within two months the bridge would not be not over the St. Lawrence River, but in it.

The effect of larger dead weight than assumed, and a lack of thorough understanding of design of large compression members built up of angles, plates and latticing, created visible problems starting in early August 1907 when the suspended span was under construction. Buckling, or small scale bending, of the lower chord plates near the pier was observed. Through a series of telegrams between the site, Cooper's office and Phoenixville, it was clear that few thought the bridge was in danger of failure. On August 29, 1908 the bridge failed, killing 75 men.

A Royal Commission appointed to investigate the failure interviewed Cooper extensively, and one of Cooper's comments stood out. He testified, "I had and have implicit confidence in the honesty and ability of Mr. Szlapka, the designing engineer of the Phoenix Bridge Co., and when I was unable to give matters the careful study that it was my duty to give them, I accepted the work to some extent upon my faith in Mr. Szlapka's ability and probity."

Two of the Royal Commission's conclusions were:

e. The failure cannot be attributed directly to any cause other than errors in judgment on the part of these two engineers. (Cooper and Henry Szlapka of the Phoenix Bridge Company)

f. These errors of judgment cannot be attributed either to lack of common professional knowledge, to neglect of duty, or to a desire to economize. The ability of the two engineers was tried in one of the most difficult professional problems of the day and proved to be insufficient for the task.

The *Engineering Record* wrote:

It is seldom that the responsible engineer for any work great or small has more authoritatively or more effectively impressed his engineering judgment upon the work in his charge than in this case... Perhaps the most painful part of the evidence is that in which the Consulting Engineer makes the plea of impaired health for not exacting from both the contractor and the Quebec Bridge Co. certain requirements of design and plans in the one case, and the necessary organization for the proper performance of the work on the other. Unfortunately, such pleas are admissions of official shortcoming: however much a man may feel the disability of ill health, they give him no relief from official responsibility. There is one only clear way by which he can divest himself of the responsibilities of official position and that is by a formal withdrawal from it... The Consulting Engineer makes a further point in his evidence that the fee he received was quite insufficient to enable him to maintain a proper office work force for the discharge of the duties imposed upon him in his official capacity... When he accepted the fee, he accepted all of the responsibilities of the position. No engineer has any right whatever to consider his responsibilities lessened because his fee is not as large as it should be... The failure of the Quebec bridge reflects in no way whatever upon the American engineering profession; it simply shows that the exactions of responsibility unfortunately make no compromise with the disabilities of age and ill health, even when combined with a meager compensation.

With this report of the Royal Commission and the sentiment expressed by the *Engineering Record*, Theodore Cooper retired from the active ranks of consulting engineers. He died on August 24, 1912, approximately five years after the collapse of the bridge that was supposed to be the capstone of his professional career. His memoir in the *Transactions* ASCE did not mention his role in the Quebec Bridge Disaster. The announcement of his death in the *New York Times* was headlined, "THEODORE COOPER, ENGINEER, DIES AT 81; Builder of Great Bridges and Assistant on First Manhattan Elevated. FORESAW QUEBEC DISASTER–His Warning Message Would Have Saved Lives—Helped Captain Eads on St. Louis Span."

While this series commemorates the great works of bridge engineers of the 19th and early 20th century, it is important to learn lessons from experiences of some of the failures that happened in the same period. Cooper was aware during the construction process that he was not able to give the project the attention it needed, and tried to resign. His resignation was not accepted, so he remained Consulting Engineer while relying more and more on the Phoenix Bridge Company to make sure the design, fabrication and erection of the bridge was safe. Theodore Cooper was a great engineer, who due to age and infirmity, failed in his responsibility to protect the public health and safety. His bridge collapsed, and the reputation of the entire profession was tarnished in the eyes of the public.▪

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